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Deputy for Systems Management
Headquarters
Aeronautical Systems Division
Wright-Patterson Air Force Base, Ohio

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SUBJECT: Contract AF 33(600)-40280; Submission of Progress Report for October 1963; Westinghouse Ref. DYD-45196

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Enclosure (1): Three (3) copies of Progress Report for the period of October 1, 1963 through October 31, 1963.

Gentlemen:

In accordance with the subject contract, we are enclosing the monthly Progress Report for October, 1963.

Very truly yours,

WESTINGHOUSE ELECTRIC CORPORATION

[redacted] STAT

Marketing Specialist
Marketing Department

RWE:sf
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cc: [redacted] (with only copy of encl.) STAT

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Progress Report

Period of October 1 to October 31, 1963

Contract No. AF33(600)40280

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A F-101 FLIGHT TEST

FILM EVALUATION

Highways, railroads, street patterns in Hagerstown, Md. and Harrisburg, Pa., airport runways and rapids in the Potomac River were resolved on correlated film from flights of this month. Also the Charles Town race track and individual buildings in military depots near Harrisburg and state penal farm near Hagerstown are resolved.

Except for very strong targets, dots in the near range are vertical and focused well over the entire sector. Well defined 2-4 mil (8.5 to 17 foot) azimuth separation of dots can be seen. Density is lower in the far range with reduced contrast, giving the impression of weak video. Noise as well as video dots change from an oblique pattern at the beginning and end of the far range film to be vertical at the center. On far range, poor focus causes rows of individual dots to blend into long azimuth targets.

Range marks are approximately 2.5 mils in range on primary film and 9 mils on correlated film. A comparison of holograms and their correlated dots determined the primary to correlated dot magnification of 1:3.5. Since the range scale factor is 1:2, this indicates range resolution is being degraded by approximately 75% in the correlation process.

Offset frequency variations were caused by poor DFT operation. On the primary film, strong low frequency video is recorded for offset frequencies below 250 cps and weak high frequency video for offset above 250 cps.

During a portion of flight S-81, the aircraft was in a right drift attitude and the antenna positioned up, causing doppler

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frequency to increase with range. The decrease in video level at long ranges because of recorder band-pass was apparent on the film.

Holograms from flight S-78 were reversed, indicating reversal of the VFO relative to the radar reference frequency. Modification to the DFT corrected the VFO and the holograms on the last three flight films showed correct polarity.

SYSTEM

Transmitter leakage into the receiver was reduced 25 db by inserting a waveguide diode switch in the RF input line of the CFA transmitter and by another 70 db by inserting a solid state coaxial switch in the 120 mc fixed frequency line to the buffer amplifier.

The doppler frequency tracker was tried on the five flights made this month. Reasons for the unsatisfactory operation of all flights are being investigated.

Tracking performance of the DFT-antenna loop was improved on the last two flights, locking up for 30 and 90 per cent of the runs. Failure to lock-up or track continuously was caused by low loop gain and inability of DFT to track at frequencies higher than 300 cps. This latter problem is caused by saturation of the four stage amplifier section of the DFT by a large return signal, thus reducing the frequency of the DFT output. Ten db receiver attenuator usually increased the DFT output about 35 cps, but at times up to 100 cps.

Only one in-flight failure was encountered, this being failure of the nylon gears on the loop motors in the recorder film transport. The nylon gears were replaced with steel gears.

INSTRUMENTATION

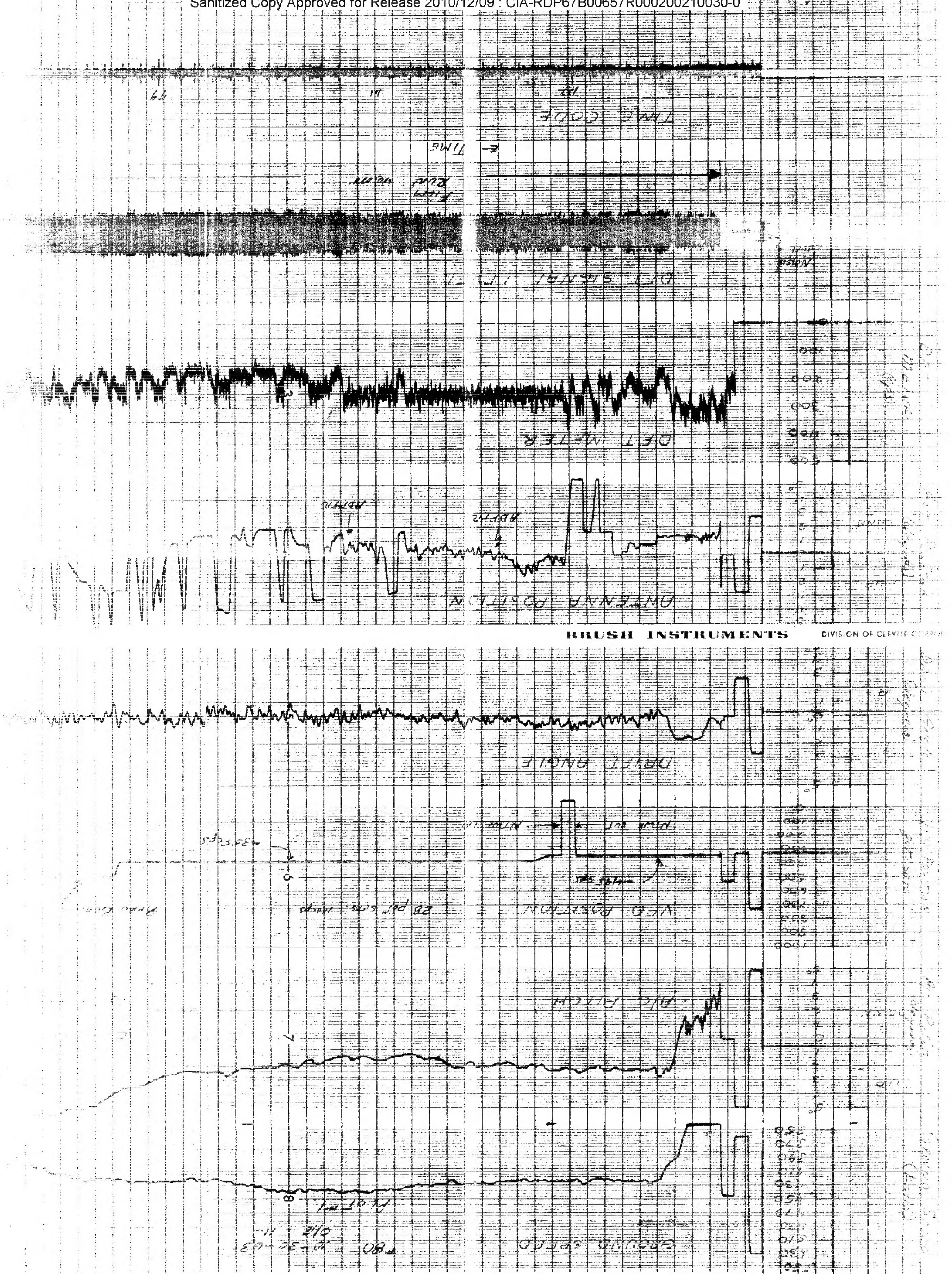
No changes have been made during the past reporting period. The failure of the magnetic tape recorder to run on flight #79 has been attributed to either brake tension on the recorder or bad tape and reels (Reeves Soundcraft). The tension was increased on the recorder, although it was not out of specification, and the "Soundcraft" reels will not be used anymore. This should eliminate the problem.

Figure 1 is a strip chart of some of the parameters recorded on flight #80. This shows the DFT tracking for about 1/3 of the run and having an oscillation of about 0.6 degrees peak to peak. These oscillations change the offset and cause noticeable striping on the final film. The effect of adding the acceleromater network caused the pod to unlock since it drove the VFO down in frequency about 1 KC.

B AIR FORCE FLIGHT TEST

The basic pulse interval for the instrumentation programmer was increased from 0.6 to 1.0 seconds to be compatible with the scan rate of the customer's digital recorder. This change required rescheduling the test modes of the programmer.

Space for the instrumentation was allocated off the frame, but located just forward of the recorder. Location of the CEC recorder was changed to make room for the tracker camera added in the equipment bay. The government furnished CEC 5-114P3 recorder has been received. Electrical design of the instrumentation and programmer is practically complete, with fabrication of half the packages underway. Completion is scheduled for January 2, 1964.


TIME CODE
TIME
DFT SIGNAL LEVEL
Noise
DFT METER
ANTENNA POSITION
BRUSH INSTRUMENTS
DIVISION OF CLEVITE CORPOR
DRIFT ANGLE
V.F.O. POSITION
A/C PITCH
GROUND SPEED

Twenty-three signals are to be recorded on the CEC analog recorder. These are:

VFO Input

Antenna Position Feedback

Input Current to Actuator

Accelerometer Output

DFT Output (Ahead of smoothing)

PESAP Input

Recorder Automatic Brightness Control

Film Drive Control

Film Drive Output Rate

Transmitted Power Output (temperature compensated thermistor bridge)

Power Supply Outputs - 7 supplies

Temperatures - 6 locations, including antenna area.

Present programmer schedule calls for normal system operation 55 per cent of a repeating 2000 second cycle. Initial plans are for normal operation to be modified for a 100 second period in each of the following modes:

Open Accelerometer

Zero Yaw and Pitch Input

Switched Offset Frequency

Open DFT

No IF Limiting

Increased Receiver Attenuation

Switched Offset Frequency and Open DFT

Switched Offset Frequency and Increased Receiver Attenuation

Swept VFO (Checks recorder azimuth bandpass)

Recorder Range Bandpass (13 mc, 26 mc and 39 mc test frequencies into video amplifier)

Instrumentation Calibration

Terrain mapping will be accomplished in all modes except the Swept VFO and Recorder Range Bandpass modes.

C ENVIRONMENTAL TEST

Three-Axis vibration tests were performed on the receiver traveling wave tube, removed from its chassis, to determine existing resonances in the tube package itself. Significant resonances were observed on the input waveguide stub. This vibration may be transferred to the tube case when the tube is mounted to its chassis.

In preparation for the antenna high temperature test, the oven was tested to insure proper temperature control. The antenna electrical test consisted of comparing the azimuth and elevation antenna patterns and main lobe gain at design and room temperatures. Patterns showed that the antenna tuned frequency decreased about 50 mc. Main lobe gain decreased about 1 db at maximum temperature relative to room temperature, with proportionately lower losses at lower temperature.

Calculations explain most of the increased antenna losses at high temperature, including:

Power divider I^2R loss	0.20 db
Stick I^2R loss	0.02
Manifold I^2R loss	0.02
Phase changes in manifold	0.34
Differential changes in power divider arms	0.09
	0.67 db

In addition, a loss is caused by the non uniform temperature

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variations on the antenna structure, particularly front-to-back.

A pressure check following the antenna temperature test indicated leakage at the waveguide joints. No other mechanical difficulties were noted during the test. Further pressure-temperature tests will be performed.

Three axis vibration tests are currently being performed on the modified lens optics recorder #6, to determine the effectiveness of the Itek modification. These comparative tests are being performed with several types of vibration isolators.

During this reporting period vibration fixtures for the SAP and SAP electronics package were designed and fabricated. Reduction of antenna vibration data from the previous period was completed.

D DESIGN EVALUATION

CORRELATOR SPATIAL FILTERING

The rough draft of a memo (STM-146) on the effects of correlator spatial frequency filtering was prepared. This included completing the computer runs of correlator output patterns with the recorder filtering present. Plots were made of the various output patterns, both with and without the recorder, and with and without a tapered gaussian filter. The recorder non-symmetry did not significantly degrade the correlation pattern.

Also included in the study was the effect of uncompensated acceleration on system resolution, as a function of the fraction of signal processed. As may be anticipated, the resolution degradation was found to decrease as the fraction of signal processed is reduced. Quantitative results were obtained, and included in the report.

FLIGHT FILM ANALYSIS

In an effort to determine all the information possible from flight films, film S-78 was studied at length for possible clues as to system malfunctions. A number of conclusions were made:

(1) The range resolution is much poorer on the correlated film than on the data film. This would appear to be due to correlator image motion.

(2) The range marks are tilted on the output film in the range direction, which would check with the image motion theory. They are straight on the data film.

(3) The recorder resolution degrades about 2/1 at the edges.

(4) There is no observable pulse pedestal with the new transmitter. This was not true with the ring.

(5) Varying the correlator slit width or filter width affects the map appearance, but does not seem to affect resolution appreciably.

(6) Azimuth resolution on weak targets approaches the design goal. On stronger targets, as expected, it degrades, but the degradation is more than expected (about 3/1 instead of 2/1).

(7) Judging by the width of the range marks and of clutter due to too low an offset, the range resolution would probably be about that anticipated if the image motion problem were eliminated.

CORRELATOR LIGHT LEVEL

A study was initiated to verify the exposure available on the output film with the present light source. The reason for interest is to extrapolate the results for a laser source. To date, results have not been in agreement with the observed exposures, and further work is indicated.

E RECORDER

RECORDER #6 TESTS

Tests made on recorder #6 showed that an 18 cycle per second (approximately 15 cycles per inch) modulation of trace position was strongly evident. Considerable effort failed to determine the cause of this flutter before the recorder was shipped. Examination of the capstan rotation failed to detect any erratic motion. Investigating for modulation of the CRT spot position by magnetic fields revealed the presence of 60 and 400 cycle components, but the limited field of the viewing microscope prevented observing 18 cycle modulation. Use of the stroboscopic effect of pulsed 18 cps on the grid was not conclusive in isolating the cause of the 18 cps flutter.

Several other difficulties were discovered. The output stage of the focus modulation circuit was unable to deliver the required 150 volts of signal without distortion, and requires further work to obtain the required level. Another difficulty was insufficient centering current to place the trace at the correct position. The recorder cannot be adjusted to 12.12 microseconds per inch writing speed. Since achievement of this writing rate requires the purchase of a new deflection yoke, the present 14 microsecond per inch capability will remain.

The Automatic Brightness Control unit operated satisfactorily. Figure 2 is a plot of the change of light output from the CRT caused by an independent voltage source varying the bias with the ABC off and ABC on. The data shows a 100:1 change in brightness with no feedback, with a change of only 1.71:1 with ABC on.

CHANGE IN BRIGHTNESS WITH INTERMITTENT
CRT BIAS SUPPLY

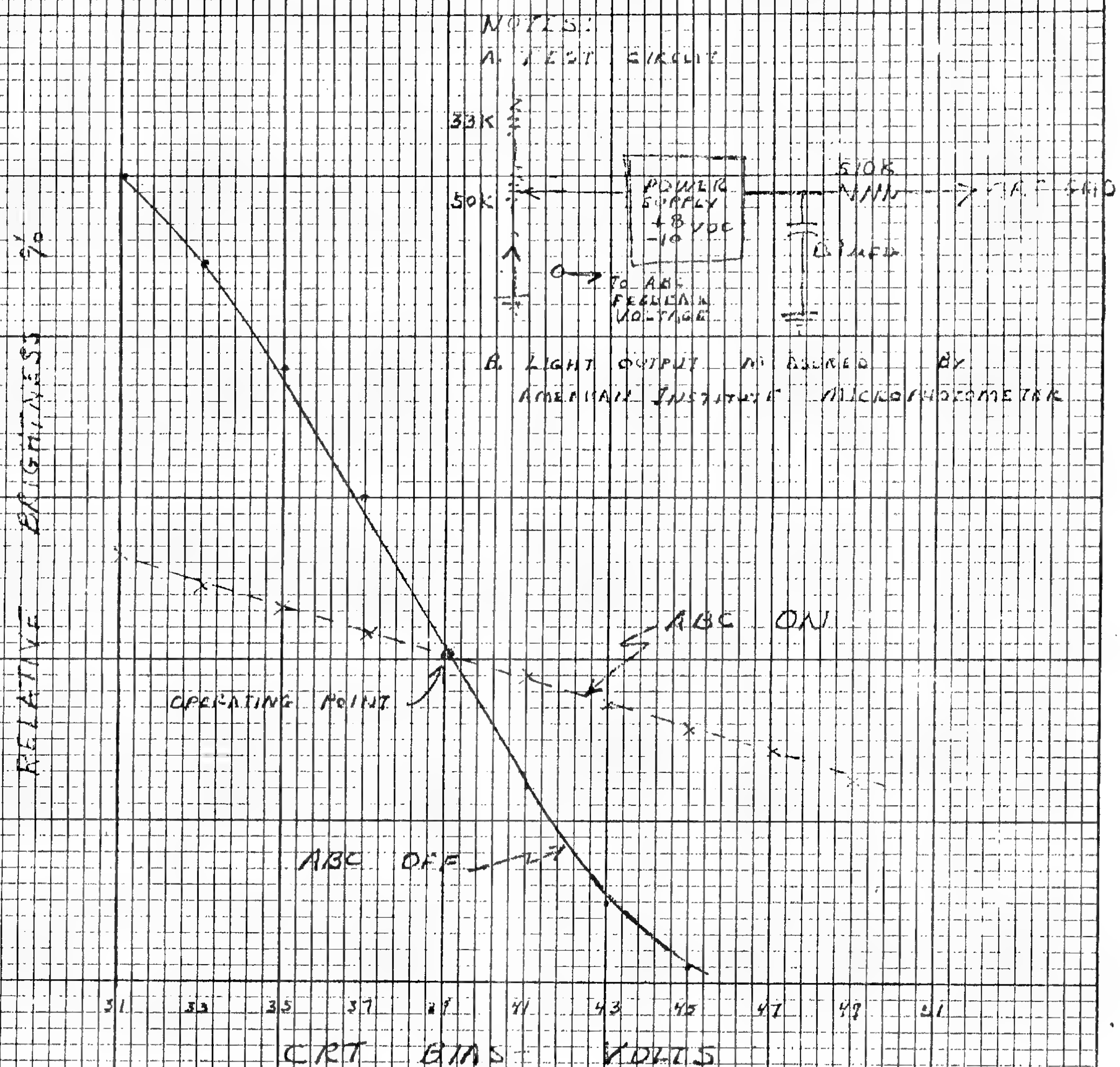

FIGURE 2

At the operating point of -39 volts bias, a 2:1 change in brightness obtained with ABC off is held to 1.1:1 change in brightness with ABC on.

LOOP-FORMING MOTOR CIRCUITRY

A check on the feasibility of 1.6 inch per second film speed resulted in an investigation of the loop motor circuitry. To change from 1.25 to 2.00 inch per second speed presently requires changing the two loop control motors, with limited range of control with rheostats. Replacing the rheostats with zener diodes allows greatly increased range of control.

Some preliminary tests were conducted on the use of transistorized speed control circuit for the loop motor controlled from the dc component of the variable speed inverter so as to permit the motors to roughly track the film speed. The microswitches would still be used to provide correction to the loops as required, but with this method the transients in film motion produced by the microswitch operation will be reduced to a minimum.

FIBER OPTIC TUBE STUDIES

The experimental fiber optic tube WX5321-P11 #1288 has been installed in a breadboard setup. The first phase of the investigation was to determine the sensitometry requirements of films for use with this tube. SO-243 (Special High Definition Aerial) film was found to be unsuitable since its low sensitivity severely limited the dynamic range of the tube. Tests with 8430 (Fine Grain Aerial Duplicating) showed this film to match the tube characteristics to a greater degree, with threshold exposures on film very

close to visual cutoff. The frequency transfer function of this film is also superior to Plus-X Aerial (4401) which is used in the lens recorders.

A reproduction of a swept frequency test on 8430 is shown in Figure 3. The noise and striations due to the fibers compare favorably with that obtained from the lens recorder from conventional cathode-ray tubes.

The film transport of the fiber-optics recorder was modified to reduce the effects of rotating magnetic components on the CRT trace and uneven belt tension to the capstan roller resulting in film flutter. The modifications included use of an aluminum capstan and drag roller instead of 440c stainless steel (at a sacrifice in concentricity) and the use of a teflon belt-tension post instead of rollers. The results of these changes were indeterminate at this time.

RECORDER #7

Recorder #7 has been completely assembled except for three items, two of which are limiting the testing. These are lenses, CRT yoke (returned to vendor for inductance change) and power supply (Fluke Power Supply can be used instead).

Several improvements have been installed on #7 and on #6 this month. These are:

1. A microscope scale and magnifier for trace measurement and microscope position indicators.

2. A magnetic shield cover for the film motion transducer.

3. A spool shaft bearing guide. This will simplify installing the cassettes and will prevent incorrect alignment.

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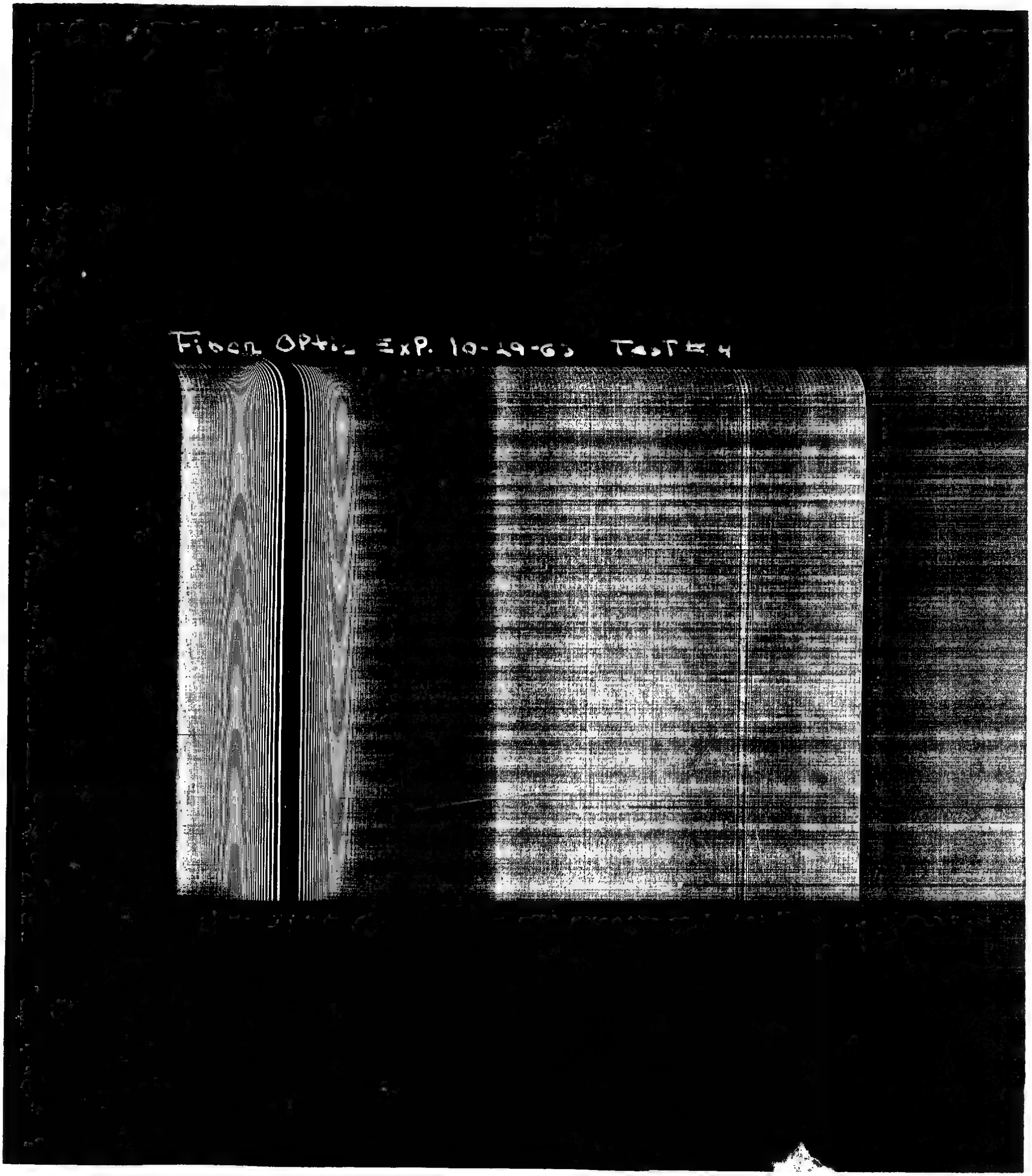
Fiber Optic Exp. 10-29-63 Test # 4

4. A cassette cover lock. This device will prevent light from entering the cassette through an ill-fitting removable cover. It will also serve to orient the cover properly so that interference between the cassettes and adjacent components will be prevented.

The two Wollensak Special Input Raptar lenses were received and underwent a resolution test on the optical bench. The visual axial resolution at f/2.8 or smaller aperture was very good, well in excess of 140 l/mm, and axial photographic resolution with Pan-Atomic X sheet film was slightly greater than 64 l/mm. However, it was discovered in these tests that both lenses had an excessive amount of field curvature. Targets 1 7/8 inches from the axis were imaged on a surface which was about0.020" inside the plane of best axial focus. The off-axis image, where it is in focus, is quite free from astigmatism and the resolution is very nearly as good as the central image. A field flattener should work very well and one is being designed.

During the testing it was also observed that there was considerable axial chromatic aberration. This, combined with the field curvature, indicated that perhaps one or more of the lens elements was fabricated from glass of the wrong index. One lens was shipped back to Wollensak for further testing.

HIGH VOLTAGE POWER SUPPLIES

Three Kaiser high voltage power supplies have failed after 20-30 hours of bench operation. Many rectifier stacks from the voltage tripler and quadrupler sections have had excessive reverse current.

One cause of the damage to the series diodes in the stack was a 4 kilocycle reverse switching current of 5 milliamperes. By inserting a 5 ohm 10 watt resistor in series with the primary of the high voltage transformer, the maximum reverse current transient was reduced to 0.1 milliamperes. Additional turns had to be added to the secondary of the high voltage transformer to provide specified output voltages. The reduction in reverse current is accomplished by a large reduction of the ringing on the secondary of the high voltage transformer.

Another source of possible trouble is the turn-on transient generated by shorting the 100 ohm series resistor in the high voltage primary. Turn on generates a fast 6 milliamperes pulse (microseconds duration) of reverse current through the diodes. The transient can be reduced to 2 milliamperes by inserting a third series resistance of 20 ohms in the primary of the high voltage transformer which is recommended to be shorted out 10 seconds shorting out the 100 ohms. With the new modifications, the power supply is less efficient but the input current does not exceed 3.0 amperes under worst conditions.

In addition, the diodes in the high voltage rectifier stacks are now selected by the manufacturer for their uniformity of reverse switching characteristics as well as equal forward voltage drop.

Power supply #9760 has been operated for a total of 42 hours with four new rectifier stacks manufactured to these tighter tolerances. The new rectifier stacks showed no degradation when removed from the supply and tested after this period. Itek plans to run the power supply an additional 50 hours during the acceptance test period.

The new high voltage precision divider resistors with a varnish binder instead of the former glass seal were also tested during the 42 hour interval. Although all the resistors displayed a slight change in value caused by temperature and voltage aging, three resistors showed an increase in resistance rather than the normal decrease.

F CATHODE RAY TUBE POWER SUPPLY

The rash of failures on the high voltage power supplies at Itek has caused a speed up in work on the new design at Westinghouse. All electrical parts have been received and one unit should be completed by November 4.

Several problems have been encountered with the subassemblies and corrected. Excessive stray capacitance in the 15 KV multiplier circuit caused a complete redesign. The 4 KV circuit design required a change in the transformer design.

G ANTENNA

All antenna design work is complete. The six spares modules have been electroformed and are complete except for the final RF tests and clean-up of the barriers and the overcoating with silicon rubber.

An antenna pod-radome test was conducted using antenna 3. No pattern deterioration was noted as caused by the radome or the pod structure. Losses of gain were .25 db one way for the radome alone and an additional .45 db for the blocking by the radome support structure.

Delamination of the varnish on the fabric covering the antenna sticks is a potential cause of trouble. A cost study is underway

to determine the costs of heat-pressure treatment of the ML fabric and the tensile tests needed to determine the improvement in the bond between adjacent layers of varnish.

Drafting on the interconnecting waveguide will be completed by 12 November, at which time the drawings will be released for fabrication. Availability of satisfactory waveguide material is the most pressing problem of this task.

Waveguide breakdown was calculated for both CW and single pulse transmission for two conditions:

(1) 68°F and 6.6 psia, corresponding to test conditions.

(2) 550°F and 20 psia (pressure established by lower tolerance on air bottle pressure regulators).

Repetitive pulse breakdown is an indeterminate function of repetition rate and pressure but limited by CW and single pulse breakdown. A breakdown of 445 KW measured under the first ambient conditions and with normal PRF is a reasonable check on the calculations.

Temperature	Pressure	Breakdown Power (KW)		
		Calculated		Repetitive Pulse
		CW	Single Pulse	
68°F	6.6 psia	362	1218	445 (measured)
550°F	20 psia	687	3930	1005 (extrapolated)

Assuming that repetitive pulse breakdown occurs at the same fraction of the difference between CW and single pulse breakdown, it is predicted that 1 megawatt is the actual breakdown at the antenna input. Taking into account the estimated 1.5 db circulator and interconnecting waveguide loss, antenna breakdown would occur at

1.4 megawatts out of the transmitter.

Both antennas 2 and 3 were power tested, with breakdown occurring at approximately the same level. Although not providing much safety factor, the antenna pressure does appear to be adequate.

Both deliverable antennas 2 and 3 were boresighted. The angle between the peak of the radiated beam and the edge of the honeycomb is 90° for both antennas. Mounting dimensions for the two antennas are accurate enough that interchanging antennas would cause an azimuth error no greater than 1/8 degree. A boresighting procedure has been written. One critical area of the antenna installation is the inclination of the longitudinal axis of the antenna. This angle shall be adjustable from the predicted flight attitude of the initial flights to that of the final flight attitude.

H TRANSMITTER

Unit testing on the first developmental model was completed after correction of 400 cps jitter on the CFA modulator and interaction between the TWT and CFA pulser. A blower was added to cool hot spots on the charging choke, charging diode, and the series transient resistor. After installation of this transmitter in the F-101, an additional pick-up problem in the TWT servo was solved.

I SYNCHRONIZER

The first deliverable Frequency Generator has been fabricated and is now undergoing test. A level set pot has been added to limit the Variable Frequency Output to 3 VRMS at 10%. Tests with the Flight Test Equipment are planned next month.

J MOTION COMPENSATION

When the first antenna yaw control actuator became available, the gain and frequency response were not as predicted by the supplier. As a result it was necessary to change the servo amplifiers and feedback in the Honeywell supplied equipment. This has been accomplished in unit #2 which has been acceptance tested and is now in Baltimore. Unit #3 is ready for acceptance test at Honeywell and unit #1 has been returned to Honeywell for these same servo modifications.

Two parameters of the actuator received from the customer are less than those given in the original design specification. The position feedback LVDT gain measures 3.8 volts per inch instead of 5.0. Gain of the actuator second stage is 40 inches/sec per inch rather than 60. After further testing with the actuator and electronics, the necessary steps to compensate for these differences will be determined.

At Aerospace the antenna has been operated in a closed loop with the yaw control electronics. It is at least controllable and stable, but measurements have not yet been made on frequency response or control accuracy.

Continuing flight test is emphasizing the relative importance of angular correction of antenna pointing and the cross track velocity compensation. The angle compensation is a matter of prime importance in obtaining a useful picture while the velocity compensation is but a small correction which improves resolution, only as a second order effect. Fortunately the deliverable system is arranged to take advantage of this situation.

K FIELD TEST EQUIPMENT

Modification of the Field Test Equipment to include circuitry for three nominal film speeds is completed. This modification includes changes in counter operation to produce the correct number of pulses to operate the Nav-Tie-In step motors and selection of ramp slopes to keep a constant focal length. All units are functioning properly and the System Test Set is complete and available for providing test functions.

Preliminary test on the system Frequency Generator indicated problems of intermodulation. This intermodulation was greatly reduced and a new series of tests is planned.